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MODELING OF OFDM BASED SYSTEM WITH OPTICAL FIBER LINK FOR PAPR REDUCTION TECHNIQUES

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ABSTRACT

Optical OFDM is a promising technology and having more advantages than wireless medium. The demand of bandwidth for higher data rate and this will meet the growing internet traffic, digital audio and video broadcasting applications growing exponentially. This paper highlights multi-dimensional while considering fiber optic communication with OFDM. To achieve good performance in optical systems, OFDM must be adapted in various ways. This paper is a review of the various PAPR reduction techniques used in optical fiber link and compares their performance in terms of transmitter power, data loss, complexity and distortion. We have considered amplitude clipping and filtering, peak windowing, coding, partial transmit sequence, selective mapping technique, tone reservation, interleaving technique and tone injection for QAM modulated OFDM. All these techniques have the potential to reduce peak to average power ratio (PAPR) at the cost of data loss. However one should make a right choice the PAPR reduction technique depending on the requirement. This study shows that amplitude clipping is the right choice as it is simple, minimum data loss if the distortion is within the tolerance limit.

KEYWORDS: Clipping and Filtering, Dispersion Compensating Fiber, Orthogonal Frequency Division Multiplexing, and Peak- to Average Power Ratio, Partial Transmits Sequence

1. INTRODUCTION

Orthogonal frequency division multiplexing (OFDM) system is to face is the accommodation of the large dynamic range of a signal. This large dynamic range, often described in terms of peak average ratio (PAPR), means that the OFDM signal has a large variation between average signal power and the maximum signal power is the disadvantage of OFDM system [1]. A large dynamic range is essential to multicarrier modulations techniques, since each subcarrier is essentially independent to each subscriber. As a result, the subcarriers can add constructively or destructively, which may achieve to large variation in signal power ratio.

It is possible for the data sequence to adjust all subcarriers tending and addition to a very large signal. Also possible for the data sequence to make all subcarriers adjust destructively and less important to a very small signal. This large variation as PAPR creates problem for transmitter and receiver design, requiring both to accommodate a large range of signal power with minimum distortion in the OFDM system. The large dynamic range of the OFDM systems presents, in particular, a challenge for the power amplifier (PA) as it works as non-linear due to PAPR and the low-noise amplifier (LNA) design. The large output drives the PA to nonlinear regions (i.e., near saturation), which causes distortion in the signal. To reduce the amount of distortion of PA and LNA to reduce the amount of out-of-band energy radiation by

the transmitter, OFDM and other modulations, alike need to ensure that the operation of a PA is limited as much as possible in the linear amplification region. This inherently large dynamic range, it means that OFDM system must keep its average power well below the nonlinear region of the PA to accommodate the signal power variations. However, reducing the average power affects the efficiency and subsequently the range, since it corresponds to a lower output power for the majority of the signal in order to accommodate infrequent peaks.

As a result, careful trade-offs between allowable distortion and output power must be made by OFDM designers; they must choose an average input level that generates sufficient output power and yet does not introduce too much interference or violate any spectral constraints. The exact value is highly dependent on the PA characteristics and other distortions in the transmitter chain. In other words, the distortions caused by peaks above this range are infrequent enough to allow for low average error rates. This paper divided into 5 sections. The section 2 will discuss PAPR of multicarrier system; section 3 will focus on PAPR reduction schemes; in section 4 we have present simulation models and results; section 5 will give the conclusion.

2. PAPR OF MULTICARRIER SYSTEM

There are several properties OFDM, which make it an attractive modulation scheme for high speed transmission links. However, one major drawback is its large peak to average power ratio (PAPR). The PAPR of an OFDM symbol is defined as the square of the maximum amplitude divided by the mean power; refer to equations, “(1),” “(2),” “(3).”

If $$S_1^1 = \max\left[s(t)\right] \tag{1}$$

Equation (1) is the maximum amplitude and equation (2) is the mean power of an OFDM symbol,

$$S_2^2 = \frac{1}{T_x}\int_0^T \left[s(t)\right]^2 dt \tag{2}$$

then the PAPR is defined as

$$PAPR = \frac{S_1^1}{S_2^2} \tag{3}$$

If all subcarriers are occupied. It allow all subcarrier phases, the time domain samples of the transmit signal are approximately Gaussian distributed. Without oversampling, the time domain samples are mutually un- correlated and the probability that the PAPR is below a certain threshold z, i.e. the cumulative distribution function (CDF), can be written as

$$P(PAPR \le Z) = CDF(Z) = (1 - e^{-z})^N \tag{4}$$

For large N and if we choose the subcarrier phases randomly, refer to “(4),” is also valid for the case of OFDM- multiple frequency-shift keying (MFSK), where not all subcarriers are utilize. However, there is a difference in the maximum PAPR in OFDM system. For the case where all subcarriers are occupied, the maximum amplitude is achieved

when all subcarriers add coherently and is $\sqrt{N}$. Due to the normalization, refer to "(1)," the mean power of such an OFDM symbol is 1. Therefore the maximum PAPR is N. If it now consider OFDM-MFSK power is 1/*M,* so that the maximum PAPR becomes *N/M.* The equation (1) for PAPR as deals with the pass band signal S(t) with a carrier frequency of f_c which is much higher than inverse of one symbol period of $S(t)$, hence the PAPR of the continuous time base band OFDM signal and its corresponding pass band signal has almost the same PAPR. But, the PAPR of discrete time baseband signal x[n], refer to "(1)," may not be the same as that for the continuous time baseband signal x(t) and it will be low, since x[n] may not have all the peaks of x(t). Measurement of the PAPR for x(t) from the PAPR of x[n] can be done by L(≥4) times interpolating the x[n]. The various PAPR reduction techniques are discussed below. The complex discrete-time base band equivalent time-domain OFDM signal can be expressed as, refer to "(5),"

$$x[n] = IFFT\ \{X[k]\} = \frac{1}{\sqrt{N}} \sum X[k] \times e^{\frac{j2\prod nk}{N}} \tag{5}$$

Where, n = discrete samples as (0, 1, 2,……, N); N → No. of subcarriers; X[k] → denotes the k^{th} modulated phase shift keying (PSK) or quadrature amplitude modulated (QAM). The PAPR of equation deals with the pass band signal S(t) with a carrier frequency of f_c which is much higher than inverse of one symbol period of $S(t)$, hence the PAPR of the continuous time base band OFDM signal x(t) and its corresponding pass band signal will have very nearly the same PAPR. But, the PAPR of discrete time baseband signal x[n], refer to "(1)," may not be the same as that for the continuous time baseband signal x(t) and it will be low, since x[n] may not have all the peaks of x(t).

2.1 PAPR Reduction Schemes

The peak to average power ratio reduction techniques with a large number of solutions have been proposed to solve the PAPR problem in OFDM. The clipping OFDM signal before amplification is a simple solution for to reduce PAPR [2]. However, clipping may cause inter-modulation among subcarriers and undesired out-of-band radiation in OFDM. Another solution for reduce PAPR is uses a block coding, where the data sequence is embedded in a larger sequence and only a subset of all the possible sequences are used, particularly, those with low peak powers [3] – [5]. While block coding reduces PAPR, it also reduces transmission rate, significantly so for a large number of subcarriers. In addition, there is no efficient coding scheme for a large number of subcarriers. Currently, a promising technique for improving the statistics of the PAPR of OFDM signals has been designed- the partial transmit sequence (PTS) technique. In the PTS technique, the input data block is divided up into disjoint sub-blocks. The sub-blocks are multiplied by phase factors and then added. Together to produce alternative transmit signals containing the same information. The phase factors, whose amplitude is usually set to 1, are selected such that the resulting PAPR is minimized. The number of allowed phase factors should not be excessively high, in order to keep the number of required side information bits and the search complexity within a reasonable limit. However, the exhaustive search complexity of the ordinary PTS technique increases exponentially with the number of sub-blocks, so it is practically not realizable for a large number of sub-blocks. The various PAPR reduction techniques are discussed below.

A. Amplitude Clipping

Studied amplitude clipping is a simple approach and the large peaks occur with a very low probability, clipping could be on effective technique for the reduction of the PAPR (O'Neill and Lopes, 1995). However, amplitude clipping is a nonlinear process and may cause significant in band distortion, which degrades the bit error rate performance, and out-of-

band noise, which reduces the spectral efficiency. The filtering after amplitude clipping can reduce the spectral splatter but may also cause some peak re-growth (Li and Cimini, 1998). To avoid this aliasing problem, each OFDM block are over sampled by padding the original input with zeros and taking a longer inverse fast Fourier transform (IFFT). The filtering after amplitude clipping is required to reduce out-of-band clipping noise. The other approach to amplitude clipping is to use Forward Error Correcting codes (FEC coding) and band pass filtering with amplitude clipping (Wulich and Goldfeld, 1999). This method improves the bit error rate performance and spectral efficiency. One of the simple and effective PAPR reduction techniques is clipping, which cancels the signal components that exceed some unchanging amplitude called clip level, A threshold value of the amplitude is set in this case to limit the peak envelope of the input signal. Signal having values higher than this pre-determined value are clipped and the rest are allowed to pass through un-disturbed,

$$B(x) = x \mid x \mid \leq A \tag{6}$$

$$= Ae^{j\phi x} \mid x \mid \geq A \tag{7}$$

Where, B(x) = the amplitude value after clipping, x = the initial signal value, A = the threshold set by the user for clipping the signal. The problem in this case is that due to amplitude clipping distortion is observed in the OFDM system which can be viewed as another source of noise. This distortion falls in both in-band and out-of-band. The filtering cannot be designed to reduce the in-band distortion and error performance degradation is observed. Another way, the spectral efficiency is hampered by out-of-band radiation. An out-of-band radiation can be reduced by filtering after clipping but this may result in some peak gradual increase. A repeated filtering and clipping can be designed to solve this problem. The desired amplitude level is achieved after several iteration of this process.

B. Peak Windowing

The simplest way to reduce the PAPR is to clip the signal, but this significantly increases the out of band radiation. A different approach is to multiply large signal peak with a Gaussian shaped window proposed by Pauli and Kuchenbeeker (1997). But, in fact any window can be used, provided it has good spectral properties (Van Nee and Wild, 1998). Since the OFDM signal is multiplied with several of these windows the resulting spectrum is a convolution of the original OFDM spectrum with the spectrum of the applied window. So, ideally the window should be as narrow band as possible. On the other hand, the window should not be too long in the time domain, because that implies that many signal samples are affected, which increases the bit error ratio. Examples of suitable window functions are the Cosine, Kaiser and Hamming window.

Van Nee and Wild (1998) showed that PAPR could be achieved independent from number of sub-carriers, at the cost of a slight increase in BER and out- of-band radiation [6] – [8]. The peak windowing method has been suggested by Van Nee and Wild. The peak windowing technique is possible to remove large peaks at the cost of a slight amount of self interference, when large peaks lying rarely. The peak windowing reduces the PAPR at the cost of increasing the BER and out-of-band radiation. The clipping is a one kind of simple PAPR reduction technique, which is self interference. The technique of peak windowing offers better PAPR reduction with better spectral properties. In peak windowing method, we multiply large signal peak with a specific window, for example; Gaussian shaped window, Cosine, Kaiser and Hamming window. In view of the fact that the OFDM signal is multiplied with several of these windows, consequential spectrum is a convolution of the original OFDM spectrum with the spectrum of the applied window. Thus, the window should be as narrow band as possible, conversely the window should not be too long in the time domain because various

signal samples are affected, which results an increase in bit error rate (BER). Windowing method, PAPRs can be obtained to 4 dB which from the number of independent subcarriers. The loss in signal-to-noise ratio (SNR) due to the signal distortion is limited to about 0.3 dB. A back of relative to maximum output power of about 5.5 dB is needed in spectra distortion at least 30 dB below the in-band spectral density.

C. Coding

A block coding scheme for reduction of PAPR proposed by Jones, Wilkin- son and Barton (1994) is to find code words with minimum PAPR from a given set of code words and map the input data blocks to these selected code words. Thus, it avoids transmitting the code words which has generates high peak envelop power. But, this reduction of PAPR is at the expense of a decrease in coding rate. It has 2.48 dB with rate block code for four carrier signal. For large number of carriers, necessary code sets exist but encoding and decoding is also difficult task. It is not suitable for higher order bit rates or large number of carriers. M sequences the use of m-sequences for PAPR reduction is proposed by Li and Ritcey (1997). This is done by mapping a block of m input bits to an m - sequences [C0, …., CN-1] of length N = (2m – 1). This results in a code rate of (m / (2m - 1)).

The m-sequences are a class of ((2m – 1), m) cyclic codes obtained from a primitive polynomial of degree m over GF (2). Tellambura (1997) showed that the achievable PAPR is only between 5 dB to 7.3 dB for m between 3 and 10. The problem with this approach is the extremely low rate for large values of m. Eetvelt, Wade and Tomlinson (1996) designed this technique to reduce PAPR in OFDM system. The method is to form four code words in which the first two bits are 00, 01, 10 and 11 respectively. The message bits are first scrambled by four fixed cyclically in equivalent m-sequences. Then one with the lowest PAPR is selected and one of the pair of bits defined earlier (i.e 00, 01, 10 and 11) is appended at the beginning of the selected sequence. At the receiver side, these first two bits are used to select the suitable descrambler. When a scrambled binary sequence data with this high proportion of 1’s or 0’s is applied to N- point IFFT-OFDM modulator system, it will be give a signal with high PAPR. A scrambled binary sequence of length 2N with a Hamming weight close to N will often generate low PAPR. Selecting structured scrambled sequence is critical. PAPR is typically reduced to 2 percent of the maximum possible value while incurring negligible redundancy in a practical system. Coding can also be used to reduce the PAPR. A simple idea introduced here is to select those code words that minimize or reduce the PAPR for transmission. This idea is illustrated here in table 1 below.

D. Partial Transmit Sequence

In the partial transmit sequence (PTS) technique, an input data block of N symbols is divided into disjoint sub blocks in OFDM. The subcarriers in each sub-block are weighted by a phase factor for that sub block. The phase factors are selected such that the PAPR of the combined signal is minimized. In the ordinary PTS technique input data block X is partitioned into M disjoint sub blocks Xm = [Xm,0, Xm,1,…., Xm,N1] ; m = 1, 2 …., M, each partitioned sub block is multiplied by a corresponding complex phase factor and the sub blocks are combined to minimize the PAPR in the time domain signal. Example: Here, it shows a simple example of the PTS technique for an OFDM system with eight subcarriers that are divided into four sub blocks. The phase factors are selected in P = 1. The adjacent sub block are partitioning for a data block X of length 8. The original data block X has a PAPR of 6.5 dB. There are 8 ways to combine the sub blocks with fixed b1 = 1. Among them [b1, b2, b3, b4] = [1, 1, 1, 1] achieves the lowest PAPR. The modified data block will be X = [1, 1, 1, 1, 1, 1, 1, 1] whose PAPR is 2.2 dB, resulting in a 4.3 dB reduction. In this case, the number of required IDFT operations is 4. The side information must be transmitted to the receiver to recover the original data block.

One way to do this is to transmit these side information bits with a separate channel other than the data channel. It is also possible to include the side information within the data block; however, this results in data rate loss.

E. Selective Mapping Technique

In the selective mapping technique (SLM) technique, the transmitter generates a set of adequate different selected data blocks, all present again the same information as the original data block, and selects the most convenience for transmission. The block diagram of the selective mapping technique (SLM) is shown in Figure 1. Each data block is multiplied by U different phase sequences, each of length N, B(u) = [bu,0, bu,1, , bu,N1], u = 1, 2,…., U, resulting in U modified data blocks. To involve unmodified data block in the set of modified data blocks, it set B (1) as the all-one vector of length N. Let us denote the modified data block for the u^{th} phase sequence as follows X (u) = [X0bu, 0, X1bu, 1… XN1bu, N1]T, u = 1, 2,…., U. In association the modified data blocks X (u), u = 1, 2… U, the one with the lowest PAPR is selected for transmission purpose. Information about the selected phase sequence should be transmitted to the receiver as side information. At the receiver, the reverse operation is performed to recover the original data block [9] – [14].

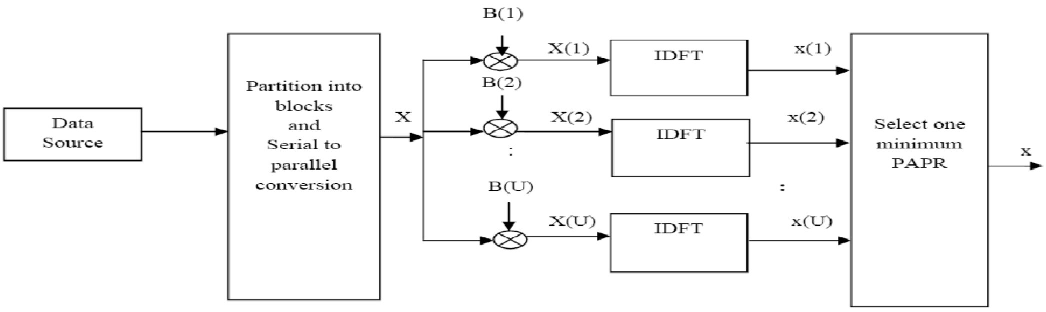

Figure 1: Selective Mapping Technique

Here, it shows a simple example of the SLM technique for an OFDM system with eight sub carriers. Set the number of phase sequences to U = 4. The data block to be transmitted is denoted X = [1, 1, 1, 1, 1, 1, 1, 1], whose PAPR before applying SLM is 6.5 dB. We set the four phase factors as B(1) = [-1, -1, 1, 1, 1, 1, 1, 1], B(2) = [1, 1,-1, -1, -1, 1, -1, 1], B(3) = [1, -1, 1, 1, -1, 1, 1, -1], and B(4) = [-1, 1, 1, 1,- 1,- 1, 1, 1]. Among the 4 modified data blocks X (u), u = 1, 2, 3, 4; X (2) has the lowest PAPR of 3.0 dB. Hence, X (2) is selected and transmitted to the receiver. For this data block, the PAPR is reduced from 6.5 to 3.0 dB, resulting in a 3.5 dB reduction.

Tone Reservation

A tone reservation (TR) technique divided the N subcarriers (tones) into data tones and peak reduction tones (PRTs). The symbols in PRTs are selected such that OFDM signal in the time domain has a lower PAPR. The position of PRTs is known to the receiver and transmitter. Figure 2 shows the block diagram of the TR scheme for PAPR reduction. Since the data tones and PRTs are exclusively assigned, the input vector to IFFT block is divided into data vector X and PAPR reduction vector C. Let R and denote the set of R PRT positions and its complement, respectively, where R denotes the number of tones reserved for peak reduction. Then the input symbols to IFFT block can be expressed as where X[k] and C[k] denote the data symbol and PRT symbol, respectively. By taking IFFT of the symbols given, we obtain the OFDM symbol to be transmitted as note that the PRT signal c[n] does not cause any distortion on the data signal x[n] in equation due to the orthogonality among subcarriers. With the TR technique, additional power is required for transmitting

the PRT symbols and the effective data rate decreases since the PRT tones work as an overhead.

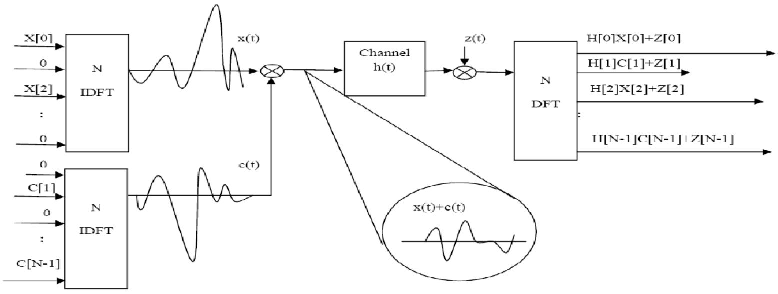

Figure 2: Tone Reservation

G. Interleaving Technique

The interleaving technique (IT) for PAPR reduction is very similar to the SLM technique. In this approach, a set of inter leavers is used to reduce the PAPR of the multicarrier signal instead of a set of phase sequences. An Inter leaver is a device that operates on a block of N symbols and re-orders or permutes them. To recover the original data block, the receiver need only know which inter leaver is used at the transmitter.

H. Tone Injection

The amount of PAPR reduction depends on the number of inter leavers and the design of the inter leavers. While the TR technique can reduce the PAPR without additional complexity, it costs the reduced data rate since the additional PRTs are required. A tone injection (TI) technique can be used to reduce the PAPR without reducing the data rate. It allows the PRTs to be overlapped with data tones. Figure 3 shows a block diagram for the TI technique. The PAPR reduction signal is constructed as C[k] = p[k].D + jq[k]. Where D is a fixed constant, while p[k] and q[k] are chosen to minimize the PAPR. The basic idea of TI technique is to increase the constellation size so that each of the points in the original constellation can be mapped into several equivalent points in the expanded constellation. Since the data tones and PRTs are not separated orthogonally in the frequency domain, it needs means of removing the effect of C[k] at the receiver.

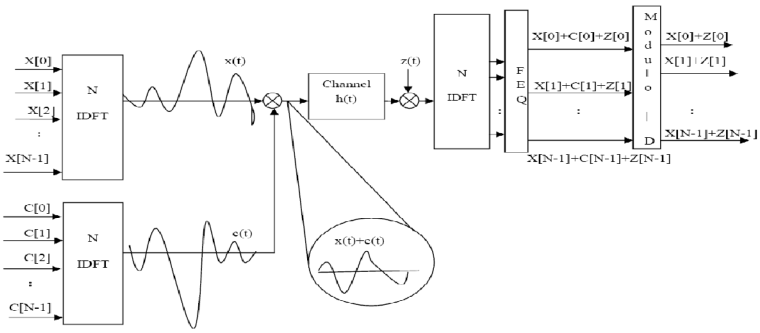

Figure 3: Tone Injection

Considering all the above techniques, it can write comparison as given in the table 1 as shown below.

Table 1: Comparison of PAPR Reduction Techniques

Techniques	Distortion Less	Power Increase	Data Rate Loss	Processing Requirement
Clipping and filtering	No	No	No	Tx: Amplitude clipping, filtering, Rx: RX: None
Coding	Yes	No	Yes	Tx: Encoding or table search Rx: Decoding or table search
PTS	Yes	No	Yes	Tx: IDFTs and complex vector sums. Rx: Side Information Extraction, Inverse PTS
SLM	Yes	No	Yes	Tx: IDFTs Rx: Side Information, Extraction, Inverse SLM
Interleaving	Yes	No	Yes	Tx: K IDFTs, interleaving. Rx: Side Information, Extraction, Inverse Interleaving
TI	Yes	Yes	Yes	Tx: IDFTs, Search for maximum point In time, tones to be modified. Rx: Modulo-D operation
TR	Yes	Yes	Yes	Tx: IDFTs. Rx: Ignore non data-bearing Subcarriers

3. OFDM SIMULATION MODEL 1 & 2 WITH SUBCARRIERS 16 AND 32

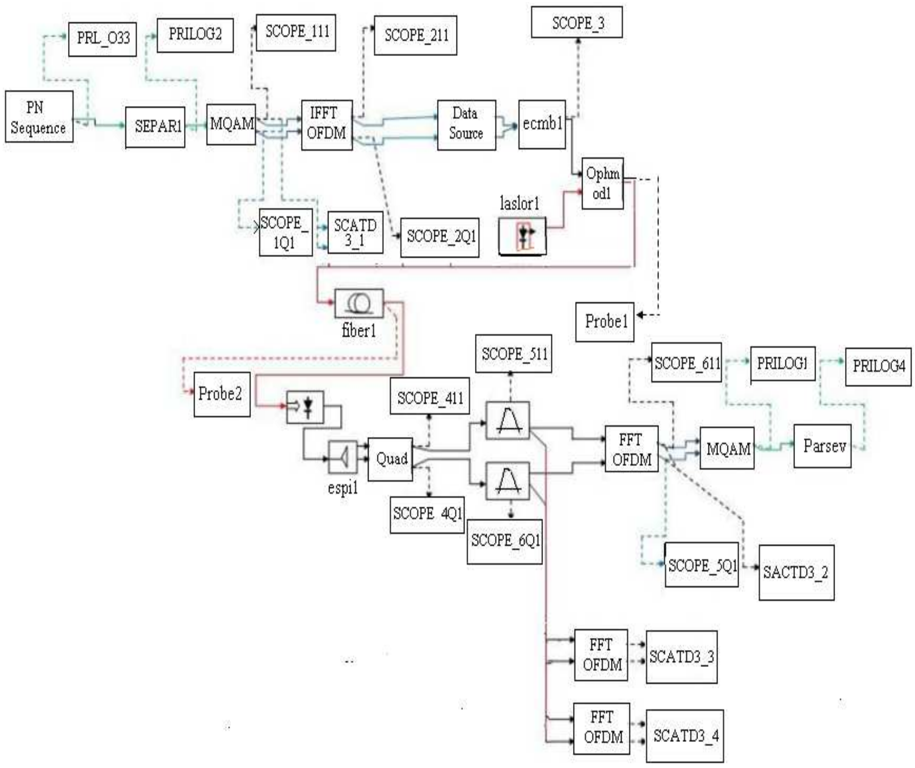

Figure 4: OFDM as Model 1 and 2 for Subcarriers 16 and 32 with Fiber 10 km

OFDM model 1 and 2 for subcarriers 16 and 32 as shown in Figure 4. The length of optical fiber between transmitter and receiver is 10 km. The various scopes are used to view results at transmitter and receiver. PRILOG icon is used to view logical signal and SCATD icon is used to view scattering diagram.

4. RESULTS AND DISCUSSIONS

Probe 1 and 2 are used to view optical spectrum at Tx of optical modulator as depicts in Figure 5 and Rx of optical photo detector with fiber 10 km as depicts in Figure 6 respectively. SCOPE icon is used to view electrical signal, electrical spectrum. Modulation scheme is QAM. IFFT is used at transmitter and FFT is used at receiver. Laser1 is the laser source whose output is modulated by OFDM signal. Photod_pin1 is PIN photodiode used at receiver to convert optical signal into electrical signal.

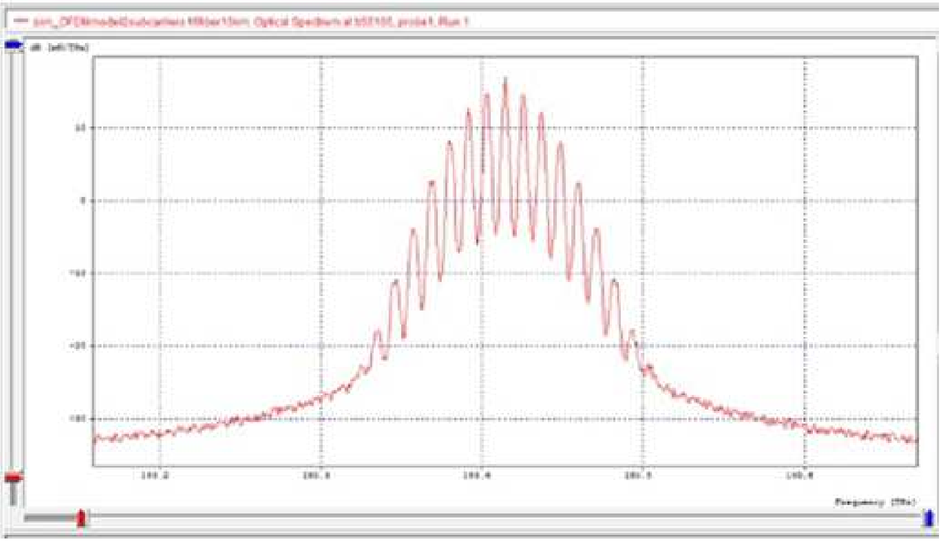

Figure 5: OFDM Model 1 with Subcarriers 16 with Probe 1 at Tx of Optical modulator as optical Spectrum

Optical spectrum of OFDM model 1 with subcarriers 16 as probe 1 at Tx of optical modulator is depicts in Figure 5. It consists of Frequency in THz along x-axis and power in dB or [mW/THz] along y axis. To view this optical spectrum, probe 1 & 2 is connected at the output of optical modulator optmod1 and fiber at 10 km connected respectively. From the Figure 5 depicts as centre frequency 193.414 THz and peak power as 10.8 dB with probe 1 and the below Figure 6 depicts as centre frequency 193.414 THz as same as at the output of optical modulator optmod1 and peak power 10.3 dB.

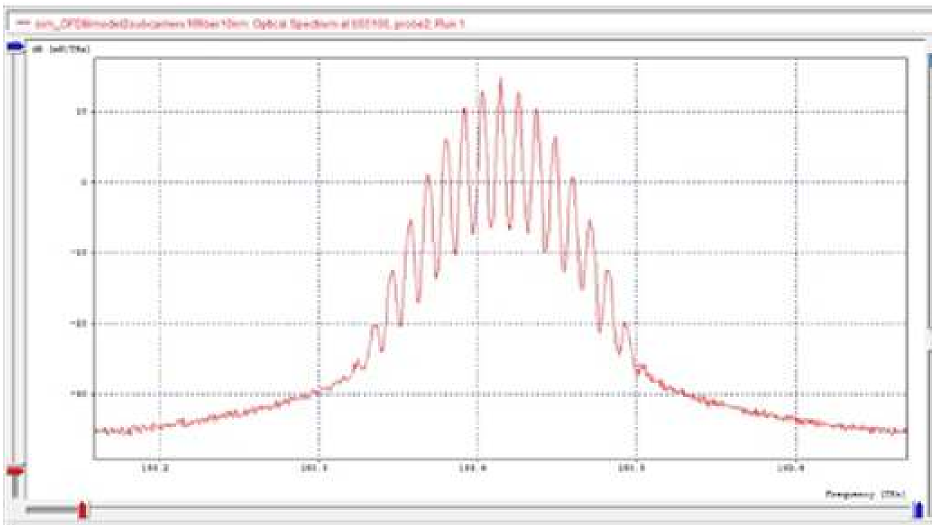

Figure 6: OFDM Model 1 with Subcarriers 16 with Probe 2 at Rx and Fiber Length 10 km as Optical Spectrum

Scattering diagram of OFDM signal with subcarriers 16 at transmitter is shown in Figure 7. A scatter plot can suggest various kinds of correlations between variables with a certain confidence interval. For example, width to height, width would be on x axis as in phase and height would be on the y axis as quadature. Correlations may be positive (rising), negative (falling), or null (uncorrelated). To view scattering diagram, SCATD3_1 is used as shown in Figure 7. The scatter plot at the receiver end after applying PAPR using SLM is as shown in Figure 7 which depicts error free transmission.

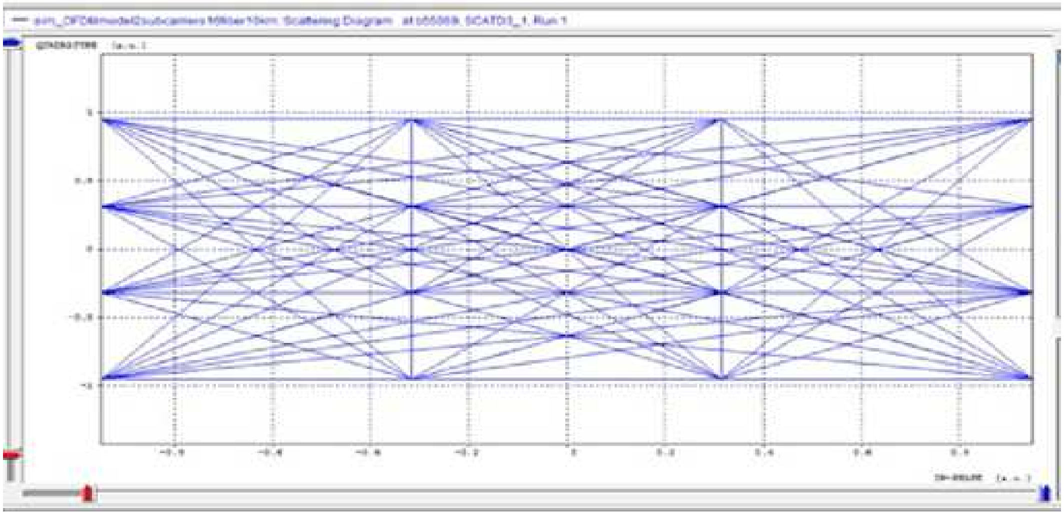

Figure 7: OFDM Model 1 for Subcarriers 16 with Fiber 10 km as Scattering Plot

Electrical spectrum of OFDM model with 2 subcarriers is shown in Figure 8. To view this electrical spectrum, scope_3 for I and Q electrical spectrum is connected at the output of combiner at the transmitter. From the plot, it can view the frequency spectrum of signal.

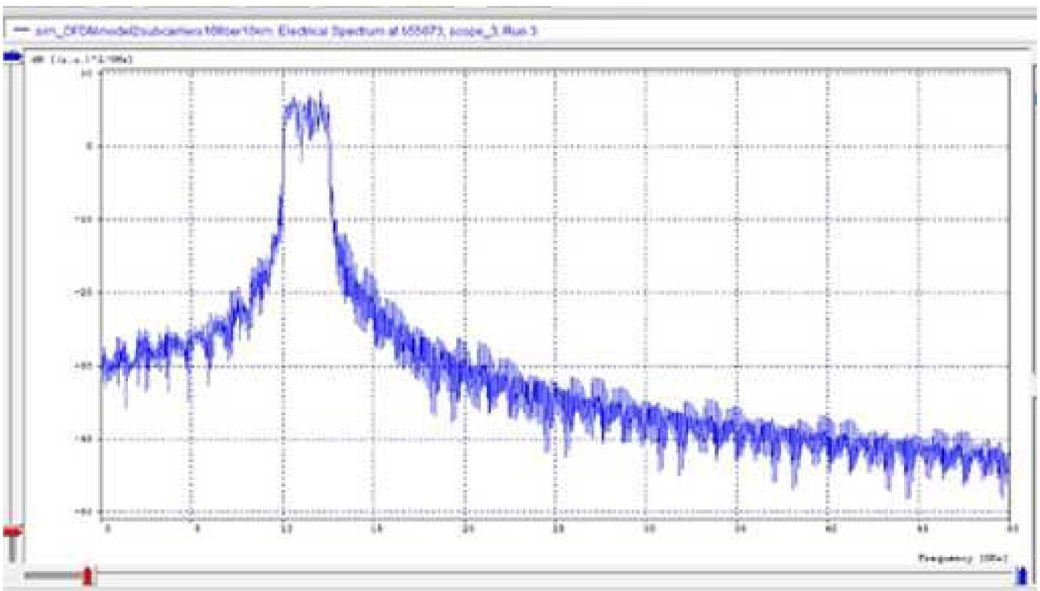

Figure 8: OFDM Model 1 for Subcarriers 16 with Fiber 10 km and Scope_3 as I and Q Electrical Spectrum

OFDM model 2 with subcarriers 32 as shown in Figure 4. The length of optical fiber between transmitter and receiver is 10 km. The various scopes are used to view results at transmitter and receiver. PRILOG icon is used to view logical signal and SCATD icon is used to view scattering diagram. Probe 1 and 2 are used to view optical spectrum at Tx

of optical modulator as depicts in Figure 9 and Rx of optical photo detector with fiber 10 km as depicts in Figure 10 respectively. SCOPE icon is used to view electrical signal, electrical spectrum, and eye diagram. Modulation scheme is QAM. IFFT is used at transmitter and FFT is used at receiver. Laser1 is the laser source whose output is modulated by OFDM signal. Photod_pin1 is PIN photodiode used at receiver to convert optical signal into electrical signal. Optical spectrum of OFDM model 2 with subcarriers 32 as probe 1 at Tx of optical modulator is depicts in Figure 9. It consists of Frequency in THz along x-axis and power in dB or [mW/THz] along y axis. To view this optical spectrum, probe 1 & 2 is connected at the output of optical modulator optmod1 and fiber at 10 km connected respectively. From the Figure 9 depicts as centre frequency 193.414 THz and peak power as 10.5 dB with probe 1 and from the below Figure 10 depicts as centre frequency 193.414 THz as same as at the output of optical modulator optmod1 and peak power 10.0 dB.

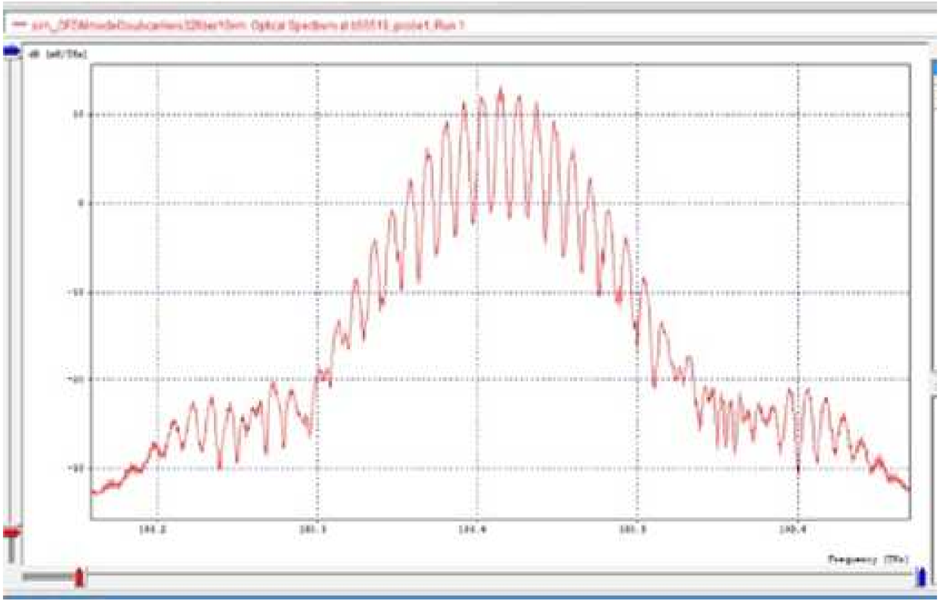

Figure 9: OFDM Model 2 with Subcarriers 32 with Probe 1 at Tx of optical Modulator as Optical Spectrum

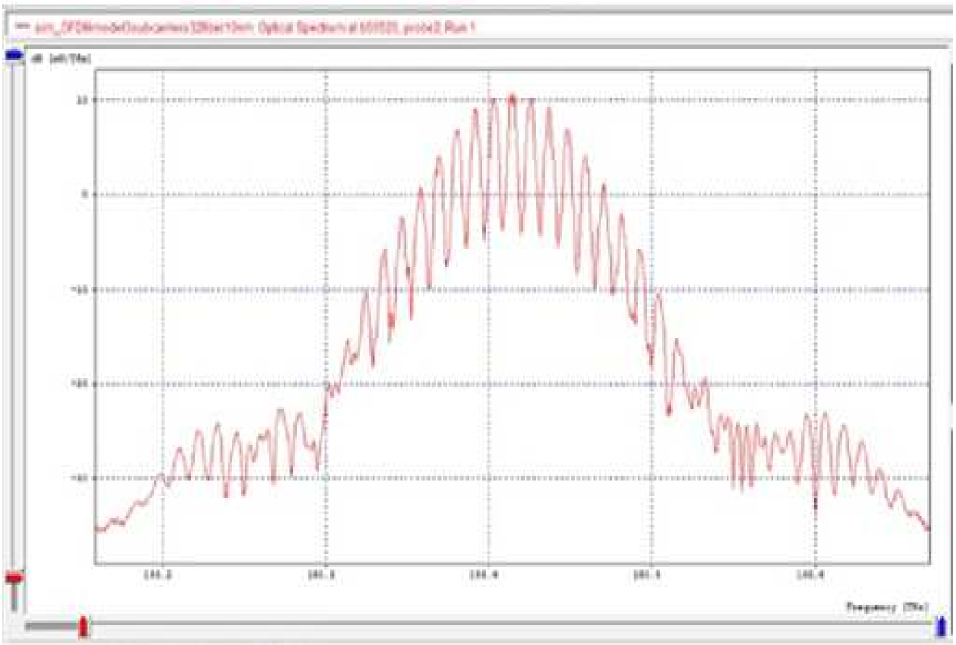

Figure 10: OFDM Model 2 with Subcarriers 32 with Probe 2 at Rx and Fiber Length 10 km as Optical Spectrum

Scattering diagram of OFDM signal with subcarriers 32 at transmitter is shown in Figure 11. A scatter plot can suggest various kinds of correlations between variables with a certain confidence interval. For example, weight and height, weight would be on x axis and height would be on the y axis. Correlations may be positive (rising), negative (falling), or null (uncorrelated). To view scattering diagram, SCATD3_1 is used as depicts in below Figure 11. Here also the scatter plot at the receiver end after applying PAPR using SLM is as shown in Figure 11 which depicts error free transmission.

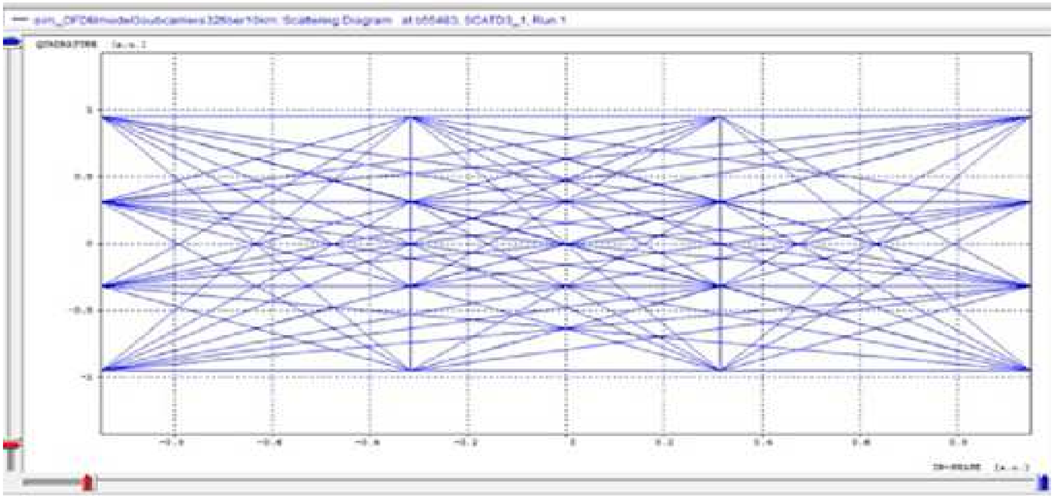

Figure 11: OFDM Model 2 for Subcarriers 32 with Fiber 10 km as Scattering Plot

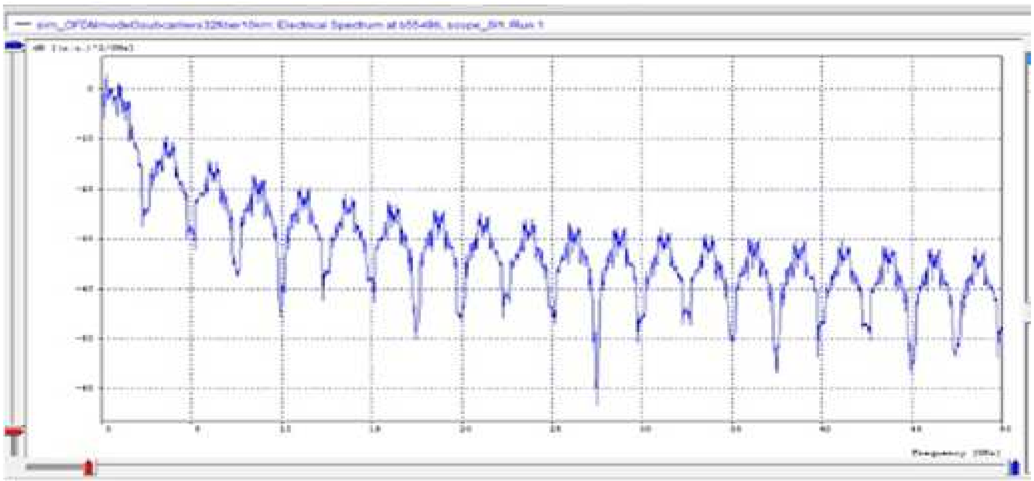

Figure 12: OFDM Model 2 Subcarriers 32 and Fiber 10 km with Scope_6 for I and Q Electrical Spectrum

Electrical spectrum of OFDM model 2 with subcarriers 32 and fiber 10 km with scope_6 for I and Q electrical spectrum is shown in Figure 12. To view this Electrical spectrum, scope 6 as I and Q is connected at the output of FFT OFDM at receiver. From plot its can view the frequency spectrum of signal.

The simulation results for selective mapping PAPR reduction techniques (SLM PAPR). The temporal response in Figure 13 shows that the recovered signal has sufficient amplitude after PAPR.

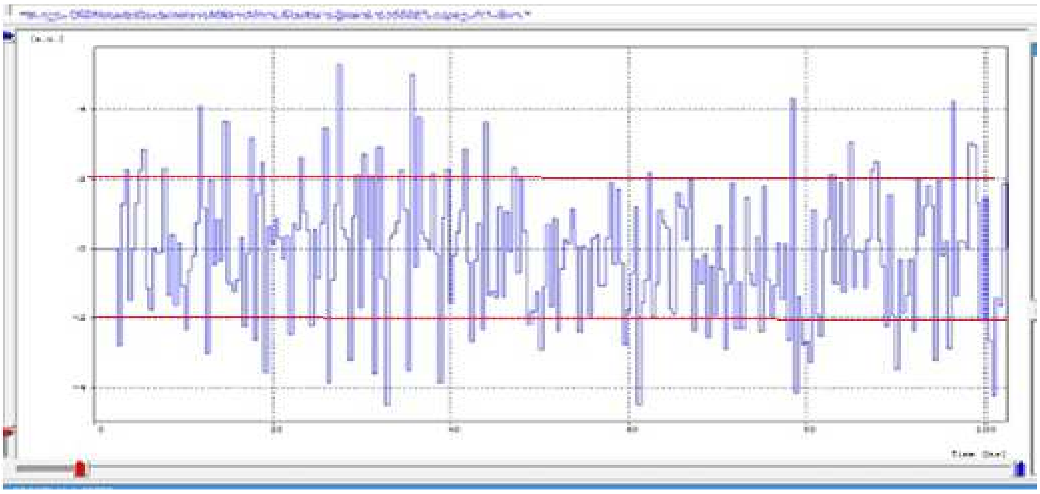

Figure 13: Temporal OFDM Signal with SLM

5. CONCLUSIONS

The multicarrier transmission is a very attractive technique for high speed transmission over a dispersive communication channel. The PAPR problem is one of the important issues to be addressed in developing multicarrier transmission systems. In writing this review, it is not able to cover every topic and mention every publication. However, subjective selection will provide new opportunities in the diverse area of science and technology. PAPR reduction techniques mentioned here are promising techniques to reduce PAPR have been proposed, all of which have the potential to provide substantial reduction in PAPR at the cost of loss in data rate, transmit signal power increase, BER increase, computational complexity increase, and so on, which can be implemented in the next generation optical networks. However, the choice of the PAPR reduction techniques is governed by the performance of the filters, D/A converters, sources and amplifiers at the transmitting side. It has analyzed and observed the OFDM model-1 and 2 with 16 and 32 subcarriers respectively, fiber where length of optical fiber between transmitter and receiver is 10 km with various scopes, and plotted optical spectrum, scattering diagram, electrical spectrum of OFDM model 1 and 2. A scatter plot suggests various kinds of correlations between variables with a certain confidence interval; it may be positive or negative. Also sensitivity of system due to timing error is determined by the rate of closure of eye.

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